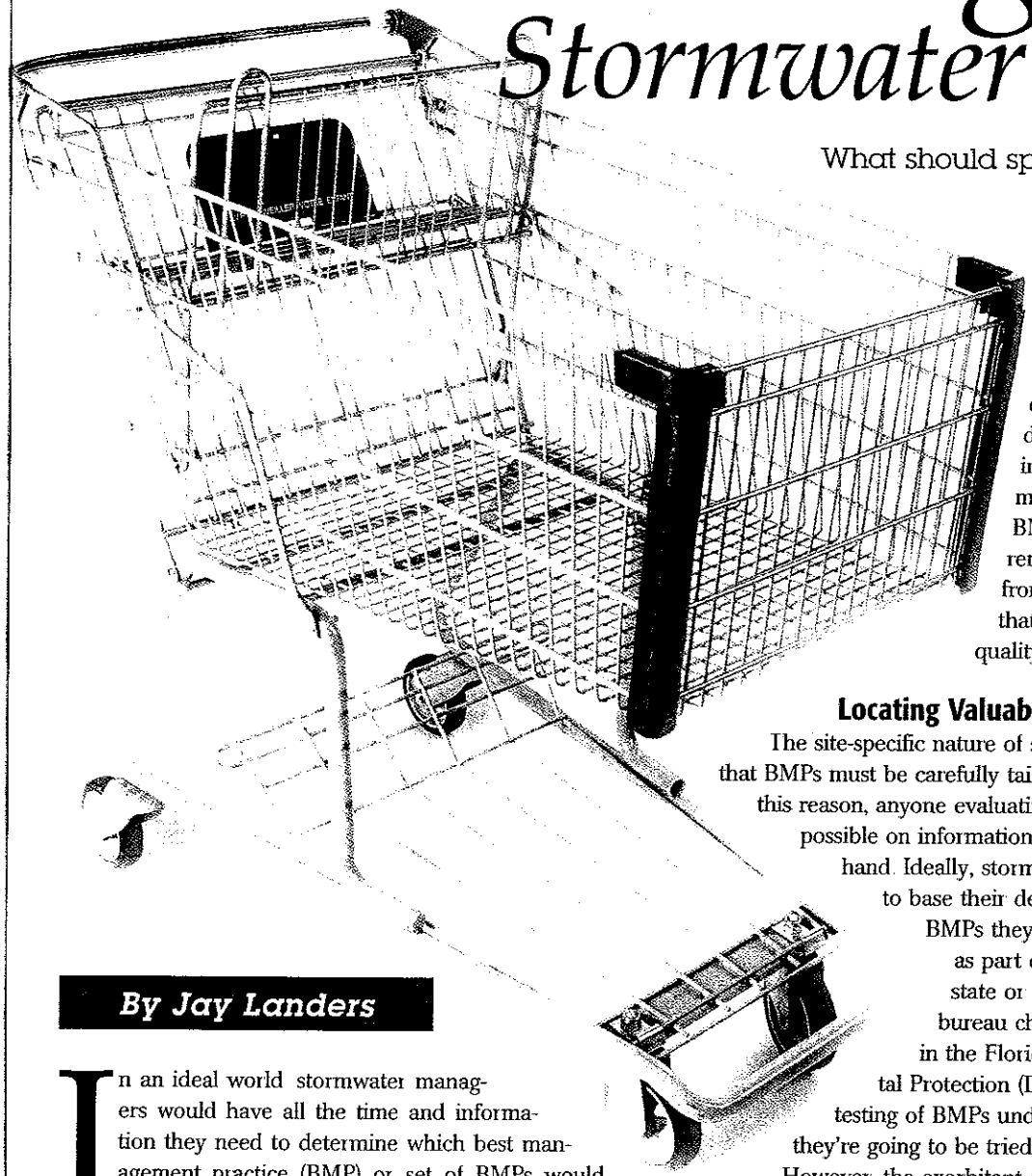
Selecting Stormwater BMPs

What should specifiers look for?



By Jay Landers

In an ideal world stormwater managers would have all the time and information they need to determine which best management practice (BMP) or set of BMPs would best fulfill a given stormwater need. Questions about maintenance needs and life cycle costs could be answered easily, and the BMP selection process would always go smoothly enjoying complete community acceptance.

Unfortunately for everyone involved with the process of selecting stormwater BMPs, the real world simply is not so accommodating. Pertinent information regarding BMP performance can be hard to come by or the information that is available may seem unclear or even contradictory. Accurate data regarding BMP costs and maintenance requirements can be even harder to locate. And a BMP that is the easiest and least expensive option to design and construct might spark the wrath of the public it is intended to benefit.

Although comparing and selecting stormwater BMPs can be a difficult proposition, a growing body of data regarding BMP performance, cost, and maintenance needs is helping improve the process. By selectively evaluating this information and developing a better understanding of the types of issues that must be addressed when selecting BMPs, stormwater managers can remove some of the uncertainty from the process and help ensure that their efforts to improve water quality succeed.

Locating Valuable Sources of Information

The site-specific nature of stormwater management means that BMPs must be carefully tailored to a given location. For this reason, anyone evaluating BMPs must rely as much as possible on information that is pertinent to the site at hand. Ideally, stormwater managers should be able to base their decisions regarding the type of BMPs they plan to use on data collected as part of testing done within the same state or region, says Eric Livingston, bureau chief for watershed management in the Florida Department of Environmental Protection (DEP). "There should be field testing of BMPs under actual site conditions where they're going to be tried," Livingston says.

However, the exorbitant cost and time requirements associated with testing BMPs in a scientifically sound manner puts that task out of reach for most local governments. Therefore, stormwater managers in states that have developed guidance documents pertaining to BMP design would do well to begin by reviewing those documents, says Ted Brown, director of watershed implementation for the Center for Watershed Protection, a nonprofit organization located in Ellicott City, MD. Yet many states have not developed such documents, Livingston notes. Finding locally relevant information on BMPs is "very difficult," Livingston says, "because very few states have taken on the challenge of trying to put this information together into some kind of document that local stormwater managers can use."

Fortunately, stormwater managers can turn to additional sources of information regarding BMP performance. For ex-

ample, Livingston recommends *National Management Measures to Control Nonpoint Source Pollution from Urban Areas*, a document re-released in November by the USEPA. The Center for Watershed Protection offers the *Stormwater Treatment Practice (STP) Pollutant Removal Database*, which summarizes more than 135 studies of stormwater BMPs. Another commonly cited reference is the California Stormwater Quality Association's *Stormwater Best Management Practice Municipal Handbook*.

Another key source of information is the International Stormwater BMP Database. Funded by a coalition of organizations, including the EPA, the American Society of Civil Engineers, the Water Environment Research Foundation (WERF), the Federal Highway Administration, and the American Public Works Association, the database currently contains data from approximately 230 studies involving more than a dozen categories of structural and nonstructural BMPs, says Eric Strecker, a principal in the Portland, OR, office of GeoSyntec Consultants. Together with Wright Water Engineers Inc. of Denver, CO, GeoSyntec maintains the database, which is available online at www.bmpdatabase.org.

Because the database is continually updated, the number of studies it contains "grows all the time," Strecker says. And with more data, the database enables a more accurate assessment of how various BMPs are functioning. "We're starting to get to the point where we can say statistically that some BMPs appear to have a different effluent quality than others," Strecker says.

The objective behind the BMP database has been to assemble "rigorous, well-reviewed studies of BMP performance" and develop documents outlining proper methods for monitoring BMPs, says Jonathan Jones, chief executive officer of Wright Water Engineers. As a result, Jones notes, the project's focus to date has been more on accumulating useful information rather than creating a database that is readily accessible to the public. "The database has been intended more for researchers and practicing engineers than it has been for people who don't have technical backgrounds and who are looking for something easy to use," Jones says.

Strecker agrees, acknowledging that using the database requires a certain level of sophistication. However, Strecker notes that a WERF document titled *Critical Assessment of Stormwater Treatment Control and Selection Issues*, published in late 2005, summarizes BMP performance data from the database in a format that is more readily accessible and easily understood.

To get the most out of the database, users should frame in advance "very clear questions" that they wish to have answered, Jones says. For example, it is helpful to confine a search of the database to a general class of BMPs that likely will work at a given site. Likewise, pollutants of primary concern should be specified ahead of time, Jones says, so that studies involving those particular constituents in locations that most closely match that of a planned BMP can be searched. Because performance can vary significantly from one BMP to another, including the same BMP during different storm events, users of the database "should be well prepared to see wide ranges in

performance," Jones says

The Water Quality Protection Center within EPA's Environmental Technology Verification (ETV) program has generated information pertaining to the performance of a handful of proprietary stormwater BMPs. Overseen by NSF International of Ann Arbor, MI, the ETV program evaluates a proprietary stormwater BMP in the field to verify whether it meets the manufacturer's claims regarding performance. For this process, an independent third party is hired to test a device according to a specific monitoring plan and write a report summarizing the device's performance, the site at which it was tested, and the conditions during the test.

Although the ETV reports provide a useful source of information about specific devices, anyone reviewing them "needs to do it with a lot of judgment and care," says Jim Bachhuber, water resource department manager for Earth Tech's office in Madison, WI. Having been involved with testing and documenting three stormwater BMPs as part of the ETV program, Bachhuber knows well that such reports have certain limitations, chief among them that different areas have varying conditions that can affect a device's performance. Other factors also need to be considered, Bachhuber says, including the frequency, intensity, and duration of storms during the monitoring period.

"Everybody wants a single number to say, 'Device *x* gets *y* amount of control of a certain pollutant,'" Bachhuber says. However, stormwater treatment includes too many variables to be condensed that simply. "Even with this pretty sophisticated information [in the ETV reports], you're going to have to make a judgment that there's some range of pollutant control that you can accomplish or achieve," Bachhuber concludes.

Although published performance data are critical, the experiences of others in the stormwater field can provide an invaluable source of information for anyone evaluating particular BMPs. "The most important thing to do is canvass local practitioners and find out what's worked and what isn't working," Jones says.

Assessing BMP Performance Data

Although information regarding detention and retention basins, constructed wetlands, bioswales, and other types of BMPs considered to be in the public domain is "scattered here and there in the literature," the data are "pretty widely available and consistent," says Michael Barrett, research associate professor in the Center for Research in Water Resources at the University of Texas at Austin. Therefore, evaluating such BMPs and comparing them to each other, while cumbersome, is possible. However, doing the same thing for proprietary BMPs is even harder, Barrett says. When it comes to assessing data regarding proprietary BMPs, he says, "For the most part, you're on a lot shakier ground when you're trying to figure out fact from fiction."

Part of the problem is the paucity of studies in which proprietary BMPs are tested side by side, according to Jones. He calls developing that type of data an "urgent and essential

need." Whenever possible, stormwater managers should rely on data that have been gathered by independent third parties, rather than the manufacturer of the device in question, Jones says. He notes that for data to be included in the International Stormwater BMP Database, it must have been collected by an independent third party in accordance with specific protocols.

In the absence of such data, however, interested observers are left to assess information provided by manufacturers. In such situations, Jones says, one should use "considerable caution and discretion when reviewing claims of manufacturers," making sure to note whether available data enable devices to be evaluated in a comparable manner. Brown, of the Center for Watershed Protection, agrees, noting that stormwater managers must review data from BMP vendors with care.

Anyone reviewing manufacturer data needs to keep in mind several questions having to do with how a device was tested, says Earth Tech's Bachhuber. For example, if a BMP was tested for its ability to remove sediment, it is important to discern what type of sediment was used in a study. Specifically, particle size is important, Bachhuber says, because larger, sand-size particles tend to settle more readily than finer particles, which often transport other pollutants such as metals. As a result, a test that employs larger particles likely will have better rates of sediment removal than one that uses smaller particles. However, "Sand-size particles aren't what you're worried about," Bachhuber says. "You're worried about the smaller stuff."

Further complicating matters, the natural environment does not lend itself to a standardized approach for testing sediment removal. Different regions have varying geologic conditions that tend to produce differing particle sizes in runoff, Barrett says. Furthermore, particle size can vary at the same site from storm to storm. A heavy rain can mobilize and transport larger particles than a drizzle can, he notes. For these reasons, "It's hard to distill that down to a standard size distribution that would be appropriate" for all testing situations, Barrett says.

Another question to keep in mind when evaluating vendor data, Bachhuber

says, is whether a study was conducted in a laboratory or in the field. Both testing environments have strengths and weaknesses that must be factored into an evaluation of study results. Laboratory testing is necessary to see how a device performs under a set of controlled conditions, Bachhuber notes, but a laboratory simulation, of course, cannot test a device under real-world conditions. On the other hand, the benefit of field testing is that it represents how a device performs under actual circumstances. And that, Bachhuber says, is also the "downside" of field testing. "It only represents what happened at that site at those rainfalls," he acknowledges.

Other questions to ponder when reviewing manufacturer data, Bachhuber says, include concern whether a device was tested under set, constant flow rates or variable flows, and whether a vendor's performance data pertain solely to the water that received treatment or if the data also include any overflows that bypassed the device. A manufacturer's calibration protocol and process for conducting quality assurance/quality control also merit scrutiny, Bachhuber says.

So can vendor data alone be used to reliably compare different proprietary BMPs? Yes, Bachhuber says, provided that the above questions can be answered, enabling stormwater professionals to "make some judgments on how well the testing was carried out by an individual vendor." However, he acknowledges that the process is far from simple. "I have a hard time doing that myself," Bachhuber admits.

The performance of public-domain and proprietary BMPs is often represented in terms of percent removal of a pollutant, generally total suspended solids (TSS). This approach has its detractors, while others view it as a useful if imperfect, measure of performance.

When it comes to assessing BMP performance, Jones says, "It's far more important and scientifically sound" to look at a practice's effluent concentration, rather than the percentage of a pollutant it typically removes. Jones maintains that he is "adamantly opposed to thinking in terms of percent removals" when evaluating BMP data. By way of example, he notes that someone interested in assessing the performance of constructed wetlands would be better off knowing that studies of, say, 20 different wetlands found that 90% of them produced effluent containing less than 20 milligrams per liter of TSS. "A statement like that has far more meaning to it than saying wetlands can typically remove 80% of total suspended solids," Jones says.

Strecker states the case more bluntly. Using percent removal to evaluate BMP performance is "just completely bogus," he says. "Percent removal is nothing more than a function of how dirty the inflow is." For this reason, Strecker says that he likes to joke that "if somebody gave me an 80% TSS removal requirement, I'd be throwing as much dirt in the parking lot as I could."

Evaluating BMPs strictly on the basis of percent TSS removal can lead to inaccurate comparisons and "unnecessary confusion," Barrett says, if one fails to consider a situation in its entirety. For example, he relates how an evaluation he once

conducted of two different sand filters indicated that one removed a substantially higher percentage of TSS. Yet the filters discharged effluent with similar concentrations of TSS. As it turns out, the filter that initially appeared to have removed more TSS was receiving runoff from a dirtier site. "Even though both devices produced exactly the same discharge quality," Barrett says, "one appeared to look worse just because it was monitored in a clean watershed."

However, regulations typically specify that BMPs achieve a certain level of pollutant removal, such as 80% removal of TSS, making it a sort of de facto standard against which many BMPs are judged. Furthermore, many BMPs rely on sedimentation as their primary means of removing pollutants, rather than targeting specific constituents such as zinc or polyaromatic hydrocarbons, Barrett says. Because the removal of TSS also tends to result in the removal of these and other pollutants, Barrett says, TSS removal can be a useful way to "rank BMPs from most effective to least effective for a wide variety of constituents."

Recognizing the limitations and the value of using percent TSS removal as a measure of performance, some regulators are beginning to look at the idea of incorporating into regulations both required TSS load reductions and a maximum concentration or an average annual concentration, Bachhuber says.

Considering Other Critical Factors

Stormwater options often vary considerably depending on whether a particular project is a new development or a retrofit situation, the Center for Watershed Protection's Brown says. Whereas a new development may enjoy few constraints in terms of where BMPs may be located, retrofit projects frequently must contend with limited space and existing utilities, factors that can complicate the process of determining which BMP to use. As a result retrofit projects may require the use of BMPs that meet less stringent standards compared to options that might be employed at a new "greenfield" site.

In addition to determining the availability of land, stormwater managers must answer a host of questions related to a given site and the receiving water before selecting a particular BMP or suite of BMPs, Strecker notes. For example, such questions might include, "What are the pollutants or parameters of concern?" Likewise, it is important to note whether a pollutant occurs in a dissolved or particulate form, Strecker says, because such factors must be considered when evaluating potential methods for removing the pollutant from runoff.

Because individual BMPs rarely remove all pollutants of concern by themselves, Strecker advises taking a "unit-process" approach to BMP selection and design. Rather than attempting to employ a single system to meet water-quality objectives, he recommends using certain performance measures to guide the process of selecting treatment options.

The first of these measures involves the extent to which a BMP reduces the amount of runoff that might otherwise occur. Strecker points out that data from the International Stormwater BMP Database indicate that some practices reduce runoff

either through infiltration or evapotranspiration. Therefore, he encourages designers to "figure out how to get back more of the sponge" at a site—that is, restore a site's ability to infiltrate or evaporate precipitation rather than discharge most of it as runoff.

Strecker next recommends that designers carefully consider the extent to which runoff volumes will be treated by a BMP. "A lot of BMPs have bypass systems, or at a certain flow rate they stop operating with any reasonable effect," Strecker says. "That's another important measure." BMPs also should be evaluated on the basis of their effluent quality and whether they are causing erosion downstream, he says.

Jones concurs with the unit-process approach. "Having multiple BMPs in series and having conservative design approaches are very helpful," he says. What's more, Jones says, using BMPs in a series helps "dampen out the variability" that can occur with any given BMP for a particular storm event.

Many manuals developed by states or local governments to assist with the process of evaluating stormwater BMPs include selection matrices. Such tools are useful, Brown says, because they help narrow a wide field of options to a smaller subset of tools appropriate to a given site. Matrices typically will consider such factors as slope, elevation difference, local soils, maintenance requirements, cost, type of receiving water, target criteria, and land use to help users generate an answer as to which specific practices should be employed. To answer that question, a number of site-specific factors need to be considered, Brown says, including slope, elevation difference, local soils, the type of receiving water, target criteria, and land use.

Because maintenance usually plays such an important role in determining how well a BMP functions, Brown recommends that careful consideration be given to this issue during the process of selecting stormwater BMPs. In fact, he says that it would be a mistake to select a practice based solely on performance data alone. A BMP must be adequately maintained in order for it to perform as anticipated.

In some cases, the ability to retrofit a given BMP in the future should be evaluated as part of the initial selection process. For example, the Port of Seattle recently developed a plan to retrofit the Seattle–Tacoma International Airport to accommodate stormwater management and treatment. The plan is driven by the fact that the airport's stormwater outfalls will have to comply with effluent standards beginning in 2008, says Ralph Nelson, water resources manager for the Seattle office of the engineering firm R.W. Beck Inc., which worked with the port to develop the airport's stormwater management plan.

"Stormwater treatment technology is rapidly changing over time," Nelson says, and today's leading technology might not be the best approach five years from now. Because effluent from the outfalls will be measured and checked for compliance, the design team realized that the port conceivably could be required to change or modify its BMPs in the future to ensure compliance with the effluent standards. Therefore, Nelson says, the designers looked for ways to make the BMPs "more flexible

or adaptable in the future." For example, he notes that the outfalls were designed with vertical drops that could be retrofitted with media filtration devices if necessary. Instead of installing media filters now, however, the port is going to wait and see if its current efforts at source control and treatment will be sufficient, Nelson says.

Beyond performance and maintenance, a host of other factors must be considered as part of any process of selecting BMPs, particularly public safety. "It's really incumbent upon designers to account for public safety," Jones says. Additional topics include BMP appearance, compatibility with existing land uses, and community acceptance.

Jones also urges stormwater managers not to wait until late in the planning process to begin evaluating BMP options. When that happens, he says, sites "tend to wind up with the smallest possible BMP that is shoehorned into a corner somewhere." In such situations, Jones notes, a BMP becomes a liability for a site, rather than an amenity.

Estimating BMP Costs

The process of evaluating various BMPs would not be complete without comparing the costs of different approaches. However, numerous factors can affect the price of installing a stormwater BMP, complicating efforts to determine BMP costs.

Developing accurate cost information about individual BMPs can be "brutal," Barrett says. Based on his experience installing and testing BMPs for the California Department of Transportation, Barrett says that stormwater professionals operating in a planning mode can generate ballpark costs for BMPs. However, Barrett advises stormwater managers to throw such estimates out the window when they begin evaluating BMPs for a specific site. A host of factors related to a site can influence a BMP's costs, Barrett notes, including geotechnical conditions, a site's topography, and local labor costs.

Even for proprietary BMPs whose capital costs are fairly fixed, the expense associated with installing them is highly variable, Bachhuber says. Site conditions, such as the presence of underground utilities, groundwater, and bedrock, can cause costs to fluctuate dramatically. "Product cost is one component," Bachhuber says, "but the installation cost is oftentimes equal to or more than the product cost."

The cost of land likewise skews efforts to accurately estimate BMP costs, says the Florida DEP's Livingston. He notes that his agency is developing a database of urban BMPs in Florida. "The most difficult element of that database is coming up with good cost information," he says. Because land in Miami, for example, typically costs more than land in rural Florida, Livingston says, it is very difficult to compare costs of projects around the state. In fact, he says, finding accurate information regarding the cost of BMPs is "much harder than trying to determine treatment effectiveness."

Costs associated with maintaining BMPs comprise yet another complicating factor, says R.W. Beck's Nelson. Because the need for maintenance can vary depending on the type of BMP

and the location, estimating maintenance costs is more difficult than developing capital costs, Nelson notes. Similarly, he says, maintenance records can vary, further impeding efforts to develop cost comparisons.

However, another report recently released by WERF attempts to account for differences in BMP maintenance requirements that can be attributed to climate and other factors. Titled *Performance and Whole Life Costs of Best Management Practices and Sustainable Urban Drainage Systems*, the report analyzes retention ponds, extended detention basins, vegetated swales, bioretention, porous pavements, and certain infiltration practices installed in the United States and the United Kingdom. The report evaluates their performance and provides a "whole-life cost model" for various BMPs based on such factors as drainage area and expected maintenance needs. Barrett, a co-author of the study, says that the report includes spreadsheets for different BMPs to enable stormwater managers to generate site-specific costs.

Finally, an accurate depiction of the expenses associated with some stormwater BMPs involves tallying any costs that were avoided as a result of employing a particular practice, Strecker says. For example, he notes that the Oregon Museum of Science and Industry, in Portland, opted to use bioswales to convey stormwater from its parking lot rather than installing typical drop inlets and pipes. In so doing, Strecker says, the museum saved $70,000. "If you just factor in the cost to build the swales, there's a cost there," he says. However, overall the project actually saved money by employing bioswales, Strecker points out. "Most of the work I see in the literature ignores" such savings, he says.

As additional BMPs are selected and installed throughout the country, such factors likely will receive greater scrutiny. By the same token, as stormwater managers continue to share their experiences with various BMPs, the process of selecting appropriate water-quality practices likely will become more straightforward and a little less daunting. ○

Stormwater contributor ***Jay Landers*** *is a writer and editor based in Austin, TX.*